Comparison between Deciduous and Permanent Incisor Teeth in Morphology of Bovine Enamel

By

Iwao SATO, Masataka SUNOHARA, Akiko MIKAMI, Shunji YOSHIDA and
Toru SATO

Department of Anatomy, School of Dentistry at Tokyo, the Nippon Dental University, Tokyo, 102-8159 Japan

— Received for Publication, February 19, 1999 —

Key Words: Bovine, Enamel, Prism, Ultrastructure

Summary: Functional incisor teeth (deciduous and permanent teeth) from *Bovidae* (14 species) were prepared for scanning electron microscopic observation. Ultrastructural patterns of the enamel layer of deciduous and permanent incisor teeth varied (ex. prisms, arrangement pattern of matrices, and in thickness of enamel layer) in each species. The ultrastructures of prisms in longitudinal sections were classified into three types; A, radial, B, tangential, and C, mix of A and B arrangement enamel; modified Koenigswald's method (1982) in examined species. Type A was found in a large part of permanent and a small part of deciduous incisor teeth, while types B and C were mainly found in the deciduous teeth.

These morphological features show the remarkable correlation between permanent and deciduous teeth.

The ultrastructural patterns of prisms in cross sections in *Insectivora*, *Chiroptera*, *Sirenia*, *Cetacea*, *Equidae*, *Primates* (Bode and Martin, 1982, 1984; Bode *et al.*, 1978; Warshawsky *et al.*, 1981), *Rodents* (Boyde, 1978; Koenigswald, 1982), and also *Multituberculates* (fossil mammal) (Carlson and Krause, 1985) have been classified into A, radial, B, tangential, and C, mix of A and B arrangement enamel. In longitudinal section of the teeth, prisms showed three patterns (Boyde, 1964, 1976); even though very few species were examined. The morphological feature of prism in *Rodent* teeth indicate the functional profiles (Koenigswald, 1982). Koenigswald and Pfreundt (1987) suggest morphological features are related to function. Therefore, the arrangement of prisms may indicate the biting ability of teeth.

This study describes the arrangement patterns of prisms in the enamel layer of the deciduous and permanent teeth of *Bovidae* species. The results of examined the morphology between deciduous and permanent incisor teeth demonstrate the functional properties of occlusal system.

Materials and Methods

We examined a total of 14 species of *Bovidae* teeth (Table 1). All the skeletons that provided teeth for this study were prepared for dried carcasses dermestid beetles, and cleaned with a brief exposure to commercial laundry bleach, followed by ten minutes in 95% ethanol. Some pieces (5–6 mm²) of teeth and other whole teeth were cut at ground tangential to the tooth surface and sectioned (about 2 mm thick) with a diamond disc. These materials were fixed for 30 minutes in 10% paraformaline solution, then dehydrated in acetone and finally embedded in epoxy resin (Epon-812). Some sections were etched with 0.1 N HCl for 15–16 sec., dehydrated in ethyl alcohol and then dried by a critical point drying method (Horridge and Tamm, 1969). They were coated with a 1.5-nm gold-palladium layer and observed under a Hitachi X-560 scanning electron microscope (SEM).

Result

The enamel layers in the examined teeth vary

Correspondence to Dr. Iwao Sato, Ph.D. Department of Anatomy, the Nippon Dental University, School of Dentistry at Tokyo, 1-9-20, Fujimi, Chiyoda-ku, Tokyo 102-8159, Japan.

Table 1. Tabulation of the bovidae taxa and specimens examined in this study

Classification	Species Examined	Specimens	Age	Sex
Order Artiodactyla				
Family Bovidae				
	<i>Tragelaphus s. strepsiceros</i>	LI ₁ (S-372)*	1D	Ma
	<i>Bos juvanicus</i>	RI ₃ (S-353)	Inf.	Ma
	<i>Oryx gazella callotis</i>	RI ₁ (S-352)	Inf.	F
	<i>gazella callotis</i>	RI ₁ (S-359)	1D	Ma
	<i>Addax nasomaculanus</i>	RI ₁ (S-213)	Inf.	
	<i>Damaliscus lunatus topi</i>	LI ₁ (S-349)	2M15D	F
	<i>Madoqua k. kirki</i>	RI ₁ (S-375)	Mat.	Ma
	<i>Gazella granti roosevelti</i>	RI ₁ (S-166)	Mat.	F
	<i>dama mhorrr</i>	LI ₁ (S-433)	3D	F
	<i>dama mhorrr</i>	LI ₁ (S-509)	7D	F
	<i>dama mhorrr</i>	LI ₁ (S-394)	42D	F
	<i>Saiga t. tatarica</i>	RI ₃ (S-535)	7Y	F
	<i>Capra aegagrus cretica</i>	LI ₃ (S-261)	Mat.	Ma
	<i>ibex sibirica</i>	LI ₂ (S-532)	5Y11M	F
	<i>Ovis orientalis gmelivi</i>	RI ₃ (S-566)	9Y5M	F
	<i>Pantholops o. ourebia</i>	RI ₁ (S-339)	Mat.	

Abbreviation: D, day; F, female; Inf., infant; M, month; Ma, male; Mat, adult; Y, year.

* San Diego State University.

from 100–200 µm in thickness (Table 2) and are clearly separated from dentine layer (Fig. 1). The average enamel layer of permanent teeth (about 200–2,700 µm) is thicker than that of deciduous teeth (about 31–500 µm). Hunter-Schreger bands are found in most permanent teeth (Table 2).

Scanning electron microscopy shows that prisms are arranged regularly with many crystals closely

packed together in different manners: A, radial enamel (Fig. 1a–b); B, tangential enamel (Fig. 1c–d); C, mix of A and B arrangement enamel (Fig. 1e–f). The interprismatic enamel is composed of many fine crystals and is found in each rod sheath. Enamel matrices have many small calcified masses (Fig. 1b, d, f). The prisms in deciduous incisor teeth are classified into various types of arrangements

Table 2. Tabulation of the enamel arrangement pattern and enamel thickness in this study

Examined Species		Arrangement Pattern* ¹	Enamel (µm) Thickness* ²	HSB* ³
Permanent Teeth				
<i>Capra</i>	<i>aegagrus cretica</i>	B	215	++* ⁴
	<i>ibex sibirica</i>	A	700	+* ⁵
<i>Madoqua</i>	<i>k. kirki</i>	C	185	++
<i>Gazella</i>	<i>granti roosevelti</i>	B	555	++
<i>Saiga</i>	<i>t. tatarica</i>	B	525	++
<i>Ovis</i>	<i>orientalis gmelivi</i>	B	860	++
<i>Pantholops</i>	<i>o. ourebia</i>	B	2,688	++
Milk Teeth				
<i>Tragelaphus</i>	<i>s. strepsiceros</i>	C	208	++
<i>Bos</i>	<i>juvanicus</i>	A	350	+
<i>Oryx</i>	<i>gazella callotis</i> (S-352)	B	517	++
	<i>gazella callotis</i> (S-359)	A	350	+
<i>Damaliscus</i>	<i>lunatus topi</i>	A	373	+
<i>Gazella</i>	<i>dama mhorrr</i> (S-433)	C	290	++
	<i>dama mhorrr</i> (S-509)	A	314	+
	<i>dama mhorrr</i> (S-394)	C	31	–* ⁶
<i>Addax</i>	<i>nasomaculanus</i>	B	390	++

*¹, see Table 1; *², maximum thickness of enamel layer; *³, Hunter-Schreger band; *⁴, very developed HSB;

*⁵, developed HSB; *⁶, non-HSB.

prisms; S-349, S-353, S-359, and S-509 are classified as type A; S-213 and S-352 are classified as type B; S-372, S-394, and S-433 are classified as type C. In contrast, the prisms in permanent incisor teeth are mainly classified as type B except for S-532 (type A) and S-375 (Type C).

Discussion

Boyde (1964, 1976) reported three patterns of prisms in cross-sectional observation of mammal teeth. There are different arrangements of prisms between deciduous and permanent incisor teeth in our examined species. Our examined species are classified into three types of the prisms in longitudinal section. Type B resembles to the classification by Boyde (1964, 1976). However, since there are previous reports about classification in prisms in term of the evolution connected with fossils (Pfretzschner, 1993) or living species (Boyde and Martin, 1982, 1984; Boyde *et al.*, 1978; Warshawsky *et al.*, 1981; Boyde, 1978; Koenigswald, 1982), we tried to investigate to functional levels in biting ability of the tooth. For example, the arrangement of prisms in mammalian teeth has a specific structure called "the Hunter-Schreger bands" which indicates the load of chewing pressure (Kawai, 1955). Pfretzschner (1986) suggested that the structural adaptation is in response the stress factor in enamel varying loading condition. The higher tensile strength of fibers is the key to structural reinforcement of the material (Koenigswald and Pfretzschner, 1991). Rensberger and Pfretzschner (1992) also suggested the specific microstructure of the canine enamel in *Astrapotheres* has resisted cracking under varied loading conditions. Therefore the Hunter-Schreger band reveals the ability in chewing pressure on the surface of enamel. In our examined species, the Hunter-Schreger band is always found in the enamel layer of permanent teeth except for Type C (S-394). A clearly defined Hunter-Schreger band is found mainly in type B. These morphological features has to reflect the load of chewing system in permanent teeth. Moreover, the enamel layer of the examined deciduous teeth has wide interprismatic enamel compared with permanent teeth, and deciduous teeth are mainly classified as type A. Type A is that where the enamel layer is composed of a wide interprismatic enamel and small prisms. Deciduous teeth are more likely to crack under chewing pressure than permanent teeth. Therefore specific morphological observations at ultrastructural levels of enamel indicate the functional profiles between deciduous and permanent teeth.

Acknowledgment

Dr. David J. Archibald (Department of Biology, College of Sciences, San Diego State university, San Diego, California, 92182-0057, U.S.A.)

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Explanation of Figures

Plate I

Fig. 1. SEM photographs of tooth in *Bovidae*. Variation in enamel ultrastructural patterns.

Type A; (a) View of enamel layer in longitudinal section of tooth in *Damaliscus lunatus topi*. Prisms are parallel each other and are separated by interprismatic enamel, and orient at right angle to the tooth surface near the outer enamel layer (bar = 10 μ m). (b) Enlargement of region of Fig. 1a (bar = 5 μ m). Type B, (c) View of enamel layer in longitudinal section of tooth in *Addax nasomaculatus*. Prisms cross each other at about right angles. They have less interprismatic enamel (bar = 10 μ m). (d) Enlargement of region of Fig. 1c (bar = 2 μ m). Type C; (e) View of enamel layer longitudinal sections of tooth in *Tragelaphus s. strepsiceros*. Two patterns, type A and B are partially mixed. (bar = 10 μ m). (f) Enlargement of region of Fig. 1e (bar = 2 μ m).

IP: interprismatic enamel, P: prism